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RESEARCH REPORT

THE TRANSFER OF HABITUATION TO ROTATION WITH RESPECT
TO THE DIRECTIONAL ASPECT OF THE VESTIBULAR REACTION

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THE TRANSFER OF HABITUATION TO ROTATION WITH RESPECT TO
THE DIRECTIONAL ASPECT OF THE VESTIBULAR REACTION

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SUMMARY

This is a study of the manner in which 'directionally' opposite vestibular stimuli, applied in close proximity, interact to influence the transfer of habituation with regard to rotation direction. Thirty human male subjects, comprising three groups of ten subjects, received clockwise and counterclockwise rotatory tests of vestibular function before and after a habituation series of 34 clockwise rotation periods. Differential treatment of the groups consisted of the rotation-time/rest-time ratios employed during the habituation series. The experimental results and literature reviewed led to the following conclusions: (1) With repeated trials in which vestibular effects are counteracted by opposing vestibular stimulation, habituation to rotation may occur but may not be manifest if the trials used to test for its presence are, in effect, stronger vestibular stimuli than those used in the habituation series. (2) Previous investigators concluded that the time over which the vestibular response may act without interference is a factor which governs the occurrence of transfer of habituation from the practiced to the unpracticed direction. This conclusion is not refuted by the present experiment. However evidence is presented which indicates that conditions of visual stimulation may be of primary importance to these transfer effects.

INTRODUCTION

Abels (1, cited in 15, p. 3) reported that pigeons with postrotational nystagmus reduced by repetitive rotation in one direction yielded post-rotational nystagmic reactions of normal duration when rotated in the opposite direction. Dodge (4, p. 20) reported that about half of the decrement in postrotational nystagmus following an extensive series of rotations in one direction transferred to the opposite and unaccustomed rotation direction, but Dorcus (5) and Holsopple (12) reported an absence of transfer effects.

An explanation of these apparently conflicting results, which has been widely accepted (6, 7, 10, 15) was offered by Holsopple (13). He was the first person to state clearly that transfer of habituation is to be expected because repeated rotations in one direction yield equal amounts of "practice" for clockwise and counterclockwise accelerations irrespective of the rotation direction. Thus either clockwise (cw) rotation or counter-clockwise (ccw) rotation produces both cw and ccw accelerations.

In attempting to reconcile his results with those of Dodge, Holsopple (13) turned to the main independent variable investigated in his previous study (12), viz., duration of rotation. The duration of rotation had been brief in his study and Holsopple reasoned that this may have prevented the habituation of the rotational reaction. (or, if you will, the postrota-tional reaction for the unpracticed direction.) Implicit in this reasoning is what might be called Holsopple's original hypothesis, i.e., the fact that with brief rotation periods, the rotational nystagmus was disturbed by the cessation of rotation and only the postrotational nystagmus progressed uninterrupted. Hence repetition of rotation gave undisturbed practice, so to speak, for the latter reaction only. An experiment which Holsopple (13) performed to test this hypothesis is summarized by Mowrer as follows: "...if the rotation interval is relatively brief, say 10 seconds, and the rest interval is relatively long, say 50 seconds, the after-nystagmus produced by rotation in the direction of practice will be less markedly reduced than the after-nystagmus produced by rotation in the opposite direction" (15, p. 17).

This summary is somewhat misleading. The three subjects (humans) in Holsopple's study exhibited little or no habituation for either direction of rotation when a 50 sec./10 sec. rotation/rest ratio was employed. From this Holsppple generalized that whenever nystagmus is not complete in intensity or duration, it will not decrease (i.e. will not be reduced by repetition of this stimulus situation.) Holsopple then selected a rotation/rest ratio of 150 sec./30 sec. (Note the 30 sec.rest is of greater duration than the mean duration of postrotational nystagmus reported by Holsopple. Hence in this series the question of interferrence between the vestibular reaction and an opposite stimulus is ostensibly irrelevant.) Results of this series obtained on the same subjects used in the original series led Holsopple to conclude that "reduction of nystagmus is a function of the time over which the response may act." (13).

Mowrer employed 60 sec./5 sec. and 5 sec./60 sec. rotation/rest ratios
with pigeons to investigate Holsopple's original hypothesis. Since pigeons
have a primary nystagmus equivalent in duration to that of humans, it would
be expected from Holsopple's results with the 50 sec./10 sec. rotation/rest
ratio that habituation should not occur for either the practiced or
unpracticed direction. Mowrer however obtained considerable reduction for
the practiced direction only with the 6 sec./54 sec. ratio and obtained
reduction for both directions with the 54 sec./6 sec. rotation/rest ratio.
This leaves us in a quandary. Mowrer's results with the 6 sec./54 sec.
ratio support Holsopple's original hypothesis which Holsopple discarded on
the basis of his work with a 50 sec./10 sec. ratio.

The present experiment differs from those performed by Mowrer and
Holsopple in the following respects: (1) The habituation series is massed
into one long session so that the rotation/rest ratio is not disturbed
repeatedly by the commencement and ending of a number of separate sessions.
Mowrer used many daily sessions and attributed certain inconsistencies
between his results and Holsopple's original hypothesis to the fact that
the end of each session permitted postrotational nystagmus to run to
completion. (2) A measure of the vestibular reaction during each trial
of the habituation series is made in the present study. Because the
conditions of vestibular stimulation, during the habituation series and
during the test trials, are different, this factor should be checked.
Holsopple and Mowrer did not report measures of the vestibular reaction
during the habituation series and apparently depended solely upon test
trials for ascertaining the presence of habituation. (3) Human subjects
with head fixed who report the oculogyral illusion (OGI) as an indicant of
the vestibular reaction in the present study are to be contrasted with (a)
Mowrer's use of pigeons as subjects and vestibular head nystagmus as an in-
dicant of the vestibular reaction and (b) Holsopple's use of human subjects
and ocular nystagmus as an indicant of the vestibular reaction.

PROCEDURE

The general plan of this experiment is to investigate Holsopple's
original hypothesis by examining the results of different groups of subjects
who received identical tests of postrotational OGI for clockwise and counter-
clockwise rotation before and after a series of 34 clockwise trials.
Differential treatment of the groups consists in the rotation/rest ratios
employed during the long series: (a) Group I receives 61.5 sec. rotation
periods separated by 5 sec. rests; (b) Group II received 6.5 sec. rotation
periods separated by 60 sec. rests; (c) Group III received a rotation/rest
ratio of 91.5 sec./90 sec.

The apparatus, which has been reported in detail elsewhere (8),
consisted of a Link trainer modified to rotate solely about its vertical
axis. S was seated in the trainer, and was instructed to observe a faint
tridimensional target rigidly secured to the trainer directly in front of
him. S indicated cessation of rotational and postrotational OGI first
effects by pressing a key which caused a light to flash directly over a

3

Standard Electric Timer in an adjoining control room. E recorded the time elapsed from the onset of acceleration until the light flashed (rotational first effect) and also from the onset of deceleration until the light flashed the second time (postrotational first effect.) It will become apparent below that during certain conditions either the rotational or postrotational effect, depending upon the condition, could not be observed. Except for these occasions, rotational and postrotational data were always recorded.

The following conditions were utilized in this experiment:

Condition A. S was rotated in a clockwise direction for 61.5 sec. with controls set to achieve an angular velocity of 16 rpm. This yielded 55 sec. of rotation at 16 rpm since about 6.5 sec. elapsed during the positive and negative acceleration periods, which lasted respectively 5.0 sec. and 1.5 sec. S observed the tridimensional target during and after rotation. Twenty seconds after cessation of the first postrotational effect, overhead illumination of the room was introduced to reduce dark adaptation. Otherwise and except for the faint light from the target, which was insufficient to make the walls visible, the experimental room was in darkness throughout Condition A.

Condition E. This situation differed from Condition A only in that rotation direction was ccw rather than cw. Average time of angular acceleration in stopping from 16 rpm to zero was 1.5 sec., i.e., equivalent to the average time of stopping for Condition A.

Condition F. This condition is the same with regard to rotation characteristics as Condition A and is differently named here as a matter of convenience. This designation will be used exclusively to refer to the situation where the interval between trials is so brief that postrotational OGI cannot run to completion prior to commencement of the next trial. The rest interval used was 5.0 sec. This brief interval prevents S from observing and reporting the end of the postrotational effect; hence with this condition, only rotational reports could be obtained.

Condition G. In this situation, Ss received 6.5 sec. rotation and 60 sec. rest. Controls were set to achieve 16 rpm in a cw direction and this angular velocity was just attained when negative acceleration commenced. Because the rotation interval was so brief, it was impossible to obtain rotational reports of oculogyral duration; however postrotational reports were obtained.

Condition H. S received cw rotation for 91.5 sec. with controls set to achieve 16 rpm. This yielded approximately 85 sec. of rotation at 16 rpm since 5.0 sec. elapsed during the positive acceleration period and 1.5 sec. elapsed during the negative acceleration period. S observed the tridimensional target during and after rotation. Twenty seconds after S had reported cessation of the first postrotational effect, overhead illumination of the room was introduced as in Condition A.

4

Thirty male subjects, 19 to 28 years of age, stationed at the U. S. Naval Air Station, Pensacola, Florida, were used in this experiment. They were divided into three groups of 10 Ss. Ss had no previous experience in this or similar experiments.

The experimental programs for the three groups were as follows:

Group I, on the first day, received instructions for the various experimental conditions followed by two indoctrination trials. Condition A (cw rotation) was employed for indoctrination trials with half of the Ss while Condition E (ccw rotation) was used with the remaining half. Enough time was alloted between and after these trials to permit question periods designed to insure a thorough understanding of the instructions by each S. This was followed by four test trials, two Condition A trials separated by a 60 sec. rest period and two Condition E trials separated by an equal period. Those subjects who had Condition A indoctrination trials, received the two Condition A test trials before the Condition E test trials while this order was reversed for those who had Condition E indoctrination trials. The change of conditions during the test trials was separated by a three minute rest interval. This completed the first day's program. Twenty-four hours later, instructions for conditions were repeated and the day's procedure was described to the Ss. At this point each S received two test trials, one under Condition E followed by one under Condition A. Three minutes separated these two trials and they in turn were separated by five minutes from the habituation series which followed. This series consisted of 34 Condition F (61.5 sec. rotation, 5 sec. rest) trials. Five minutes after this series was completed, the four test trials were readministered, i.e., each S received a replication of the initial test series.

Group II and Group III programs differed from that of Group I in only one respect: the habituation series consisted of Condition G trials for Group II and Condition H trials for Group III instead of Condition F trials as in the case of Group I.

RESULTS

Two situations which bring about reduction of the vestibular reaction should be distinguished from one another: (1) Decrement in response duration may occur on any one trial as a result of some extraneous condition, such as interference by opposing vestibular stimulation. Reduction of the vestibular reaction by the experimental conditions of a specific trial will be referred to as trial decrement. (2) The reduction which sometimes occurs over a series of trials apparently as a result of repetitive vestibular stimulation is designated as series decrement.

Series Decrement as Revealed by Test Trials. It is apparent from Fig. 1 in which the test trials before and after the habituation series are compared, that Group III exhibited a definite series decrement, whereas Groups I and II exhibited little or no series decrement. Table 1 presents the results of t tests (for related measures) of the statistical reliability of

5

the differences between the test trials administered before and after the habituation series. The two cw test trials were averaged as were the two ccw test trials, giving each S one cw score and one ccw score before the habituation series. This was done for the test trials after the habituation series also, and the statistical comparisons indicated in Table 1 are based on scores computed in this manner. It should be noted that the Group III series decrements revealed by these test trials are not attributable to chance but that any series decrements for Groups 1 and 11 are easily attributable to chance fluctuations.

A mean difference of o. 'v 0.21 sec. between the cw and ccw trials before the habituation series in the case of Group III can be attributed to chance (Mean cw = 25.16 sec.; Mean ccw = 24.95 sec.; t = 0.45; df = 9; p > 0.60). The same comparison made after the habituation series reveals a mean difference of 1.00 sec. between the cw and ccw trials, and this difference is also attributable to chance (Mean cw = 18.93 sec.; Mean ccw = 19.93 sec.; t = 1.30; df = 9; p > 0.20). This is tantamount to saying that the series decrement for cw trials produced by the habituation series consisting exclusively of cw trials is not significantly different from that of the unpracticed ccw trials. Although the per cent reduction was small it was present in about equal amounts for both the unpracticed (20.1% reduction) and practiced (24.8% reduction) rotation directions. The original data upon which all of the above statistical comparisons are based are presented in Table 2.

It will be remembered that both groups received two test trials just before commencement of the habituation series in order to permit a check for maintenance of any practice effects from the test trials of the previous day. It is apparent from Fig. 2 that any series decrement which had occurred during the test trials on the first day had dissipated by the following day.

Series Decrement as Revealed by the Habituation Series. A curious aspect of the data yielded by Group I is the low starting point and apparently systematic increment in the first four trials where there was counteraction of the rotational effects by the effects of the previous deceleratory stimulus (trials 2, 3, 4 and 5 of the habituation series). That the mean differences between these four trials may be attributable to some systematic factor is indicated in Table 3. However selection of these points for comparison was made from inspection of Fig. 2, hence it is possible that the reliability of the differences between trials (Table 3) may be misleading. This question can be settled by replication of the experiment, but cannot be settled by further inference from the present data. This is also applicable to the question as to whether there is a series decrement within the habituation series of Group 1. Commencing with Trial 5 there appears to be a gradual decrement of response duration. Comparing Trial 5 with Trial 34 indicates that there is a reliable difference (t = 2.50; df = 9; p < 0.05) between these trials and hence a series decrement. However as already mentioned, the a posteriori selection of the trials for comparison vitiates, to some extent, the conclusion that this series decrement is not attributable to chance.

6

Group II shows a gradual but definite series decrement over the habituation series. The mean of the first five trials was 11.86 sec. as compared with 9.90 sec., the mean of the last five trials. The difference between these two means is statistically reliable (t = 2.33; df = 9; p < .05). Comparison of the mean of the first trial with the mean of the 34th trial, 11.59 sec. and 9.17 sec. respectively, affords another indication that the series decrement is not attributable to chance (Mean difference = 2.42; t = 2.41; df = 9; p < .05).

Figure 3 presents the Group III mean durations for each of the 34 trials constituting the habituation series as well as for the test trials before and after this series. The Group III series decrement, as revealed in the habituation series and also by comparing the initial and final test trials, is apparent in this figure.

It is important to note that although Group II did not manifest a series decrement when the test trials before and after the habituation series were compared, there is a series decrement within the Condition G trials of the habituation series. This mean decrement of 2.42 sec. from the initial to the final Condition G trial is 20.9% of the initial Condition G trial mean. This is very close to the percent reduction similarly obtained with Group III. The latter had an initial mean duration of 25.62 sec. and a final mean duration of 19.0 sec., a mean series decrement within the habituation series of 6.62 sec. This drop is 25.8% of the initial duration. Hence although the absolute series decrement was noticeably greater for Group III, the percent reduction within the habituation series was about the same for Groups II and III.

Trial Decrement Produced by Interaction between Opposite Vestibular Reactions. This experiment provides data on the trial decrement produced by the overlap of acceleratory and deceleratory stimulus effects. Figure 2 shows quite clearly that trial decrement is present for Groups I and II; test trials, either before or after the habituation series, are of significantly greater duration than the trials of the habituation series. Because with Group I the rest between trials was so brief that postrotational effects did not subside before the next rotation period commenced, only rotational effects could be reported by these subjects. Accordingly, the data plotted in Fig. 2 for Group I are the group means for the rotational first effect of CGI. In the interest of consistency, Group I rotational data are plotted for the test trials in Fig. 2. Group II data plotted in Fig. 2 are postrotational results. In Figs. 2 and 3, the test trials plotted are based on means computed over Conditions A and E (cw and ccw rotation respectively). This was done because in the test trials, half of the Ss in each group had the cw trials first (Condition A) and half had the ccw trials first (Condition E). Since there was no difference between Condition A and Condition E results, the data were combined to reveal any effects of practice within the test trials.

It may be noted that the first trial of the habituation series for Group I is of much longer duration than any of the other trials of this series and, as a matter of fact, is of the same duration as the test trials. This is due to the fact that the test trial which preceded the commencement

7

of the habituation series occurred long enough before it, so that there was no interference between the acceleratory stimulus (initiating the first trial) and the deceleratory effects from the previous test trial. Hence the first trial of the habituation series for Group I should have been of the same duration as the test trials.

DISCUSSION

Holsopple's original hypothesis, as it was interpreted by the present writer, was not supported by the results of this experiment. Group I, which received approximately 60 sec. periods of rotation separated by 5 sec. rest intervals, was expected to exhibit habituation or postrotational effects for the unpracticed direction only. Group II, which received approximately 5 sec. periods of rotation separated by 60 sec. rest intervals, was expected to exhibit habituation of postrotational effects for the practiced direction only. The test trials administered before and after the habituation series failed to give evidence of habituation for either direction of rotation for either of these groups.

This however is striking confirmation to the results obtained by Holsopple with a 50 sec./10 sec. rotation/rest ratio. It will be remembered that Holsopple also failed to obtain evidence of habituation in this situation and then generalized that "whenever the nystagmus is not complete in intensity or duration it will not decrease." To understand the implications of Holsopple's results for this generalization, it is necessary to know that when a given nystagmus, A, is interfered with by the stimulus for an opposite nystagmus, B, then not only is the duration of nystagmus A reduced (trial reduction) but the duration of nystagmus B will also be reduced (trial reduction). In other words not only would the postrotational nystagmus from a 50 sec. rotation be terminated by the commencement of a new trial in 10 sec. but the rotational nystagmus of this new trial would also be reduced by virtue of the previous interference. Trial reduction for OGI effects also has been demonstrated lucidly by Clark and Graybiel (2, 3) and is apparent in the results of the present study.

With a rotation/rest ratio of 54 sec./6 sec., such as Mowrer used, the rotational nystagmus would run to completion only on the first trial of a series since all other trials in the series would be commenced during the postrotational nystagmus from the preceding trial. The postrotational nystagmus would run to completion only on the last trial of a series since the commencement of the following trial would counteract it elsewhere in the series. Since Mowrer used a number of daily sessions and since the nystagmus of both directions could run to completion once per session, a reduction for both rotation directions as well as an equal reduction would be expected and that is what Mowrer obtained.

However Mowrer also employed a 6 sec./54 sec. rotation/rest ratio. Under this condition neither the rotational nor the postrotational nystagmus can run to completion regardless of the trial position within the series (again assuming that pigeons react to the overlap of positive and negative acceleration like humans), and hence there should be no reduction of

8

postrotational nystagmus for either rotation direction according to Holsopple's generalization that whenever nystagmus is not complete in intensity or duration it will not be subject to habituation. Mowrer however interpreted his finding of significant reduction in the practiced direction and little or no reduction in the unpracticed direction as supporting Holsopple's original hypothesis.

Because Mowrer's experimental animals (pigeons) compensated for rotation of the body by movements of the head, it is quite conceivable that a given rotation/rest ratio had a different influence upon his Ss than it did upon the human Ss who, in Holsopple's and the present study, had their heads fixed. With a gradual angular acceleration a pigeon may compensate to the extent that the acceleratory stimulus produces only slight deviation of the cupula. If a sudden deceleration is then applied, S may receive a very strong deceleratory stimulus. It is even plausible to assume that with pigeons as subjects the average effective acceleratory stimulus would be much weaker than the average effective deceleratory stimulus whenever the rotation/rest ratio is such that the latter occurs before the effects of the former have dissipated. This could be true even though the actual positive and negative accelerations applied to the body are exactly equal. When a pigeon is rotated in a cw direction, for example, positive angular acceleration sets up head nystagmus with a ccw slow phase. The latency of response, being very slight, permits the response to partially compensate for any continuation of the acceleratory stimulus. Because the slow phase is many times longer than the fast phase of nystagmus, the deceleratory stimulus by chance alone will be applied many more times during the slow phase than during the fast phase provided it is applied before the acceleratory nystagmus dissipates. This means that the head will usually be moving in a ccw direction when the deceleratory stimulus is applied to the entire body. Both the nystagmic head movement and the deceleratory stimulus applied to the body would tend to displace the cupula in the same direction. Hence the effective deceleratory stimulus applied to pigeons rotated with heads free may be as strong when the effects of acceleration and deceleration overlap as when sufficient time is permitted between these two stimuli to avoid such an overlap. Because there is not complete certainty as to how the nystagmic head movements affect the cupula, replication of Mowrer's experiments with a 6 sec./54 sec. rotation/rest ratio, where the reactions of pigeons during the habituation series (as well as the results of the test trials) are recorded, would be interesting.

That the effective strength of the vestibular stimulus may be an important factor in transfer phenomena is suggested by the results of the present experiment. Group II manifested no habituation for either rotation direction in the test trials and yet exhibited a series decrement in the habituation series. Group III exhibited habituation in both the test trials and the habituation series, but only slightly greater per cent reduction was obtained with Group III during the habituation series than with Group II.

Now let us examine the habituation series of these two groups. Group II received 6.5 sec. rotations separated by 60 sec. rests. In each

rotation period, 5.0 sec. of the 6.5 sec. were consumed by positive angular acceleration and the remaining 1.5 sec. were used in negative angular acceleration. Hence the negative acceleration followed the positive acceleration without delay. This means that the cupula was greatly deviated in a position exactly opposite to that which the negative acceleration would tend to induce. Hence in terms of the vestibular end organ, Group II during the habituation series received a stimulus for postrotational effects which was equivalent to a much weaker stimulus applied without the interference of positive acceleration effects. Comparing the duration of the postrotational effects yielded by Group II during the habituation series with other experimental results suggests that the stimulus for the postrotational effect was equivalent to deceleration from angular velocity of 2 or 3 rpm at a rate of $60^\circ/\text{sec.}^2$. Group III, on the other hand, received 90 sec. periods of rotation at 16 rpm separated by 90 sec. rest intervals throughout the habituation series. With this program there was no interference between the effects of positive and negative accelerations.

The test trials received by Groups II and III were identical. Both groups received 60 sec. periods of rotation at 16 rpm separated by at least two minutes of rest. Thus both groups received strong vestibular stimuli during the test trials but only Group III received equally as strong vestibular stimuli during the habituation series. It is proposed herein that the failure of Group II to evidence habituation in the test trials is not due to a lack of habituation in Group II but to a failure of the habituation which occurred in the habituation series to transfer to the much stronger vestibular stimulation which occurred in the test trials. This is in line with the results of previous experimentation (9).

Holsopple concluded from his results with a 150 sec./30 sec. rotation/rest ratio that habituatory reduction of nystagmus is a function of the time over which the response may act. This hypothesis, however, is not yet well defined. For example, the postrotational reactions as reported by Holsopple were complete within 30 sec. Ostensibly then, the postrotational response had finished its 'action' but Holsopple suggests that this response did not have enough 'time to act' to permit habituation. Some recent work by Clark and Graybiel (2, 3) may provide an answer to this apparent paradox. They investigated different intervals between acceleration and deceleration and found that the secondary vestibular reaction still indicated the presence of interaction between the effects of opposite vestibular stimuli even after the primary reaction had failed to reflect a change in the experimental variable. Since Holsopple was apparently reporting the primary vestibular reaction, it is possible that the postrotational reactions of his subjects were not complete within 30 sec. These considerations plus the rather scant empirical evidence which serves as a basis for this hypothesis indicates the need for further experimentation along these lines.

On the other hand, it seems quite possible that conditions of visual stimulation may account for the occasional findings of unequal reductions of the vestibular reaction for the practiced and unpracticed rotation

directions. Dodge reported that about half of the decrement in postrotational nystagmus following an extensive series of rotations in one direction transferred to the opposite and unaccustomed rotation direction, but Abels, Dorcus and Holsopple (1, 5, 12) reported an absence of transference. It is perhaps significant that, of these experiments, the only one in which vision was excluded is also the only one which indicates the presence of transfer effects. In view of Abels' early finding of no transfer to the unaccustomed direction with vision permitted, but with vision excluded a definite transfer effect, it is surprising that this factor has been neglected.

Rotational nystagmus for cw rotation is equivalent in many respects to postrotational nystagmus for ccw rotation. This considered in conjunction with the fact that vision facilitates rotational nystagmus and reduces postrotational nystagmus makes understandable the possible generalization that the presence of vision may differentially affect habituation with regard to rotation direction.

Further perusal of the literature brings surprising support for the importance of visual stimulation in transfer effects. King (14) reported a difference in the reduction of rotational and postrotational nystagmus with vision permitted, a difference which was not present when vision was excluded. This has also been found in human subjects using OGI as an indicant of the vestibular reaction (8, 9). Mowrer (15, p. 37) found a lack of transfer of habituation of postrotational nystagmus from the practiced to the unpracticed direction when vision was permitted during and after rotation, but reports that another group, similarly treated except that vision was excluded, exhibited almost complete transfer of habituation. Halstead (11) found marked evidence for transfer in pigeons with vision excluded. Although Holsopple (12) reported that habituation of postrotational nystagmus for one direction seemed to have little effect on the postrotational nystagmus for the opposite direction, he did report that two subjects, rotated with vision excluded during and after rotation, exhibited a significant transfer effect.

The fact that the presence or absence of vision seems sufficient to account for the lack uniformity of the results which have direct bearing on the question of transfer from the practiced to the unpracticed rotation direction has received little attention heretofore although recognized by some (cf. 15, p. 17).

The present results in conjunction with the foregoing analysis of reports by Holsopple and Mowrer suggest the following:

(1) Where the effects of positive and negative angular accelerations overlap, habituation to rotation may occur but this habituation may not be revealed by test trials administered before and after the habituation series, provided that these trials are, in effect, stronger vestibular stimuli than those used in the habituation series.

(2) Holsopple's original hypothesis (as interpreted by this writer and as interpreted by Mowrer) should be discarded. It does not predict an

11

unequal reduction in the practiced and unpracticed rotation directions, regardless of what rotation/rest ratio is employed.

(3) Holsopple's generalization that habituation is dependent upon the time over which the response may act should be checked by further experimentation. Because of literature reviewed herein, the writer favors another explanation for the lack of uniformity in results relating to the transfer of habituation from the practiced to the unpracticed rotation directions, namely the lack of uniformity in conditions of visual stimulation among the experiments which seem to conflict.

(4) Mowrer's work, in which he investigated rotation/rest ratios with pigeons, should be repeated and the habituation series as well as the test trials should be recorded.

REFERENCES

1. Abels, H. Über Fachempfindung im Gebiete der kinästhetischen und statischen Sinnes; ein Beitrag zur Lehre von Bewegungschwindel. Z. Psychol. Physiol. Sinnesorg., 1906, 43, 268-289; 374-422.

2. Clark, W. B., & Graybiel, A. The lag effect associated with stimulation of the semicircular canals as indicated by the oculogyral illusion. U. S. Naval School of Aviation Medicine, Project NM 001 059.01.25, Research Report No. 25, 17 November 1950.

3. Clark, B., & Graybiel, A. The duration of the oculogyral illusion as a function of the interval between positive and negative acceleration. U. S. Naval School of Aviation Medicine, Project No. NM 001 059.01.28, Research Report No. 28, 1 February 1952.

4. Dodge, R. Habituation to rotation. J. exp. Psychol., 1923, 6, 1-35.

5. Dorcus, R. M. A comparison of post-rotation nystagmus duration for repeated stimulation with the head fixed and free. J. comp. Psychol., 1927, 7, 177-179.

6. Dunlap, K. Adaptation of nystagmus to repeated caloric stimulation in rabbits. J. comp. Psychol., 1925, 5, 485-493.

7. Dunlap, K., & Dorcus, R. M. The effect of rate of retardation on post-rotation nystagmus. J. comp. Psychol., 1926, 6, 329-335.

8. Guedry, F. E., Jr. The retention of effects of 'massed' and 'distributed' vestibular stimulation as indicated by the duration of the oculogyral illusion. U. S. Naval School of Aviation Medicine and Tulane University, Project No. NM 001 063.01.33, Joint Project Report No. 33, 1 July 1953.

9. Guedry, F. E., Jr. The transfer of habituation to rotation with respect to the magnitude of the vestibular stimulus. U. S. Naval School of Aviation Medicine and Tulane University, Project No. NM 001 063.01.34, Joint Project Report No. 34, 10 July 1953.

10. Fearing, F. S. Post-rotational head nystagmus in adult pigeons. J. comp. Psychol., 1926, 6, 115-131.

11. Halstead, W. The effects of cerebellar lesions upon the habituation of post-rotational nystagmus. Comp. Psychol. Monogr., 1935, 12, 1-130.

12. Holsopple, J. Q. Some effects of duration and direction of rotation on post-rotation nystagmus. J. comp. Psychol., 1923, 3, 85-100.

13. Holsopple, J. Q. An explanation for the unequal reductions in post-rotation nystagmus following rotation practice in only one direction. J. comp. Psychol., 1924, 4, 185-193.

14. King, B. G. The influence of repeated rotations on decerebrate and on blinded squabs. J. comp. Psychol., 1926, 6, 399-421.

15. Mowrer, O. E. The modification of vestibular nystagmus by means of repeated elicitation. Comp. Psychol. Monogr., 1934, 9, 1-48.

Table 1

Examination of Test Trials Before and After the Habituation
Series for the Presence of Series Decrements

	Group I		Group II		Group III	
	cw	ccw	cw	ccw	cw	ccw
Mean Before	22.62	22.35	22.74	22.42	25.16	24.95
Mean After	22.49	21.37	23.17	21.91	18.93	19.90
t	0.09	0.89	0.44	0.48	6.23	4.88
df	9	9	9	9	9	9
P <	0.90	0.40	0.70	0.70	0.001	0.001

Table 2

Test Trials Before and After The Habituation Series

Group	Order of Test Trial	Subject	cv Before 1	2	cv After 1	2	ccv Before 1	2	ccv After 1	2
I	cv First	1	22.9	21.7	19.6	20.5	26.1	23.7	21.2	23.7
		2	24.0	19.6	29.3	26.3	21.7	20.1	28.0	21.8
		3	23.8	24.3	25.1	24.6	22.5	23.5	18.4	20.0
		4	17.0	15.5	15.3	16.4	14.9	13.4	16.8	16.7
		5	24.0	23.7	26.5	26.0	27.5	27.8	29.0	30.3
	ccv First	6	22.8	23.7	26.0	25.6	22.3	23.5	25.5	23.9
		7	20.5	21.5	16.1	18.5	21.2	23.9	16.0	18.7
		8	27.8	27.3	22.1	22.7	22.8	27.1	17.8	20.5
		9	20.9	20.0	16.0	15.5	21.6	19.8	18.6	17.8
		10	26.2	25.3	28.9	28.6	20.6	23.0	19.9	22.8
II	cv First	1	17.0	15.5	17.6	18.5	15.7	13.8	15.4	15.3
		2	19.9	15.6	17.8	14.9	19.7	19.3	17.3	15.9
		3	23.1	18.7	19.0	17.4	20.9	20.7	21.5	20.8
		4	24.9	19.0	27.8	25.7	20.8	20.0	25.1	20.9
		5	21.8	21.7	26.3	26.5	22.2	17.9	22.9	23.9
	ccv First	6	25.5	22.8	25.8	24.1	21.0	19.8	18.8	24.0
		7	20.8	23.6	22.6	23.3	25.8	23.3	17.4	18.2
		8	26.5	30.3	25.3	22.9	30.2	31.3	26.5	24.8
		9	27.2	30.5	28.7	23.9	24.8	26.0	28.7	26.1
		10	26.0	24.5	28.9	25.6	28.1	27.0	28.3	26.4
III	cv First	1	22.9	18.6	7.7	10.8	21.0	20.8	12.3	10.5
		2	30.6	29.2	22.5	15.8	31.4	31.4	21.7	21.6
		3	26.5	27.3	19.1	21.3	31.2	26.2	23.5	22.8
		4	12.8	13.9	9.3	9.1	14.5	12.0	12.0	12.9
		5	26.5	20.5	16.7	18.3	23.9	24.2	17.6	20.2
	ccv First	6	26.8	25.8	19.5	20.2	25.4	26.8	19.8	19.9
		7	24.9	25.5	17.8	19.3	25.4	25.6	19.5	18.1
		8	34.2	31.2	26.1	28.9	33.3	29.7	28.7	27.0
		9	18.8	17.8	16.4	19.2	18.3	12.3	13.8	11.6
		10	32.2	37.2	32.9	27.7	30.0	35.6	33.2	31.9

Table 3

Variance Analysis of Data from Trials 2, 3, 4,
and 5 of the Group I Habituation Series

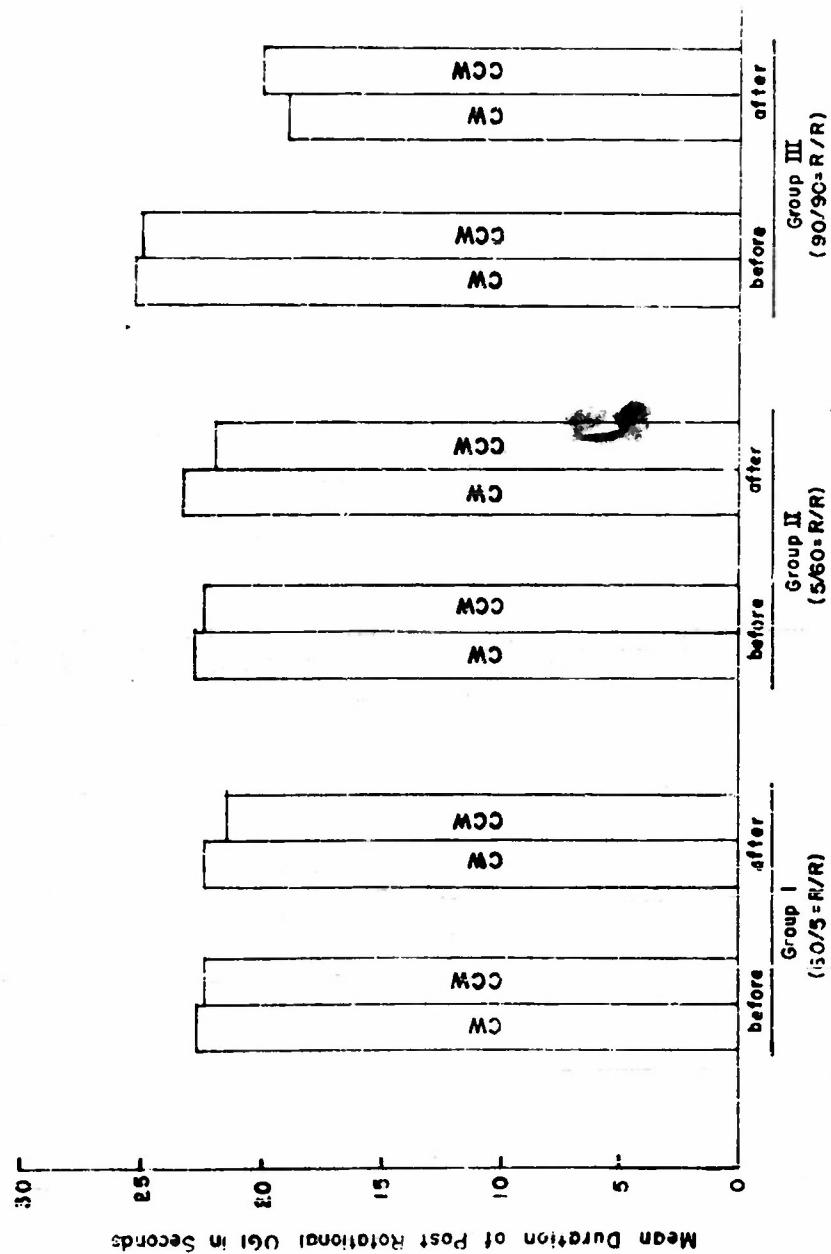| Source	Σx^2	df	Mean Square	F
Between Trials	88.06	3	26.02	4.99
Between Subjects	624.92	9	69.44	13.32
Ss x Trials	140.71	27	5.21	
Total	853.69	39		

FIG. I COMPARISON OF TEST TRIALS BEFORE AND AFTER THE HABITUATION SERIES.
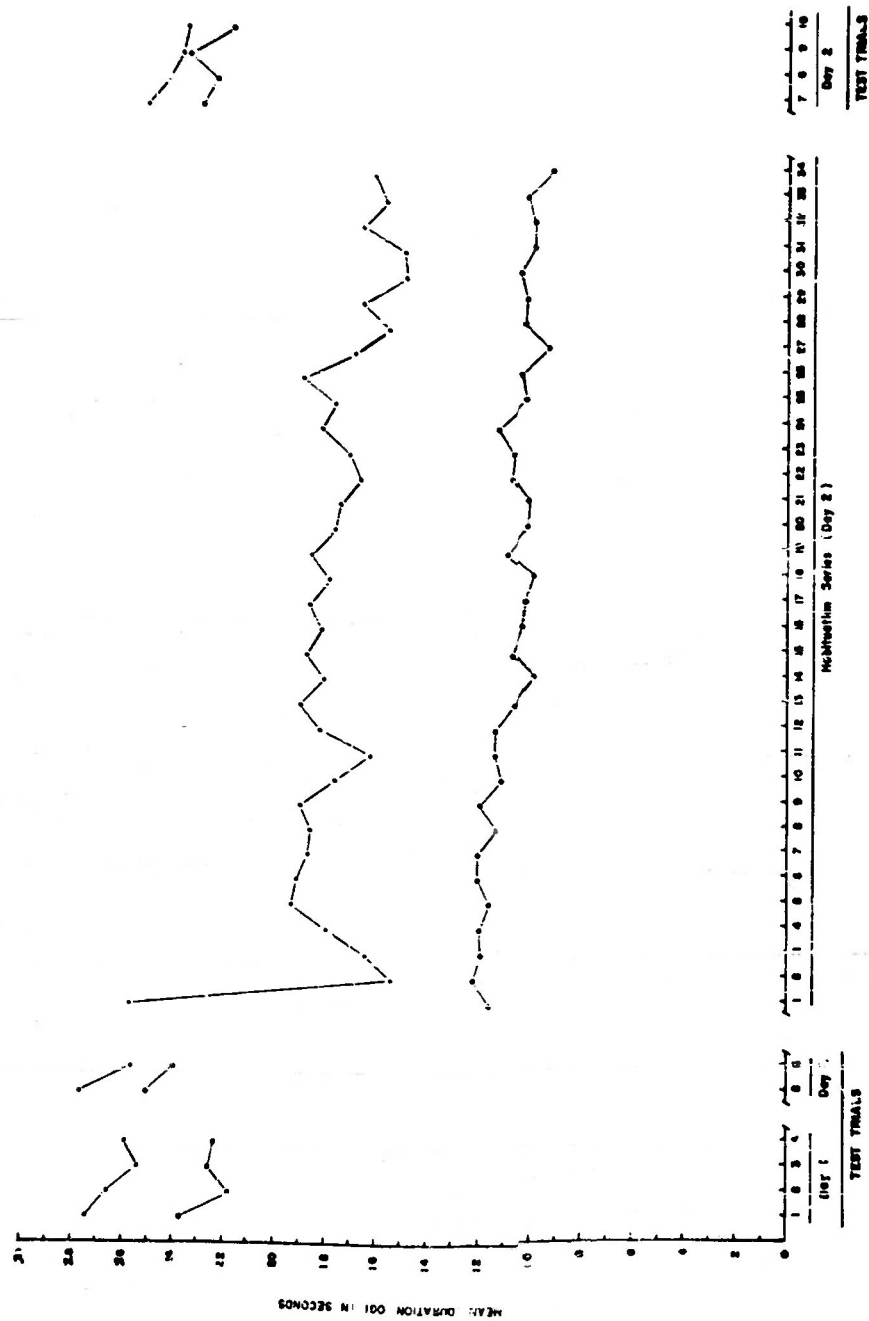
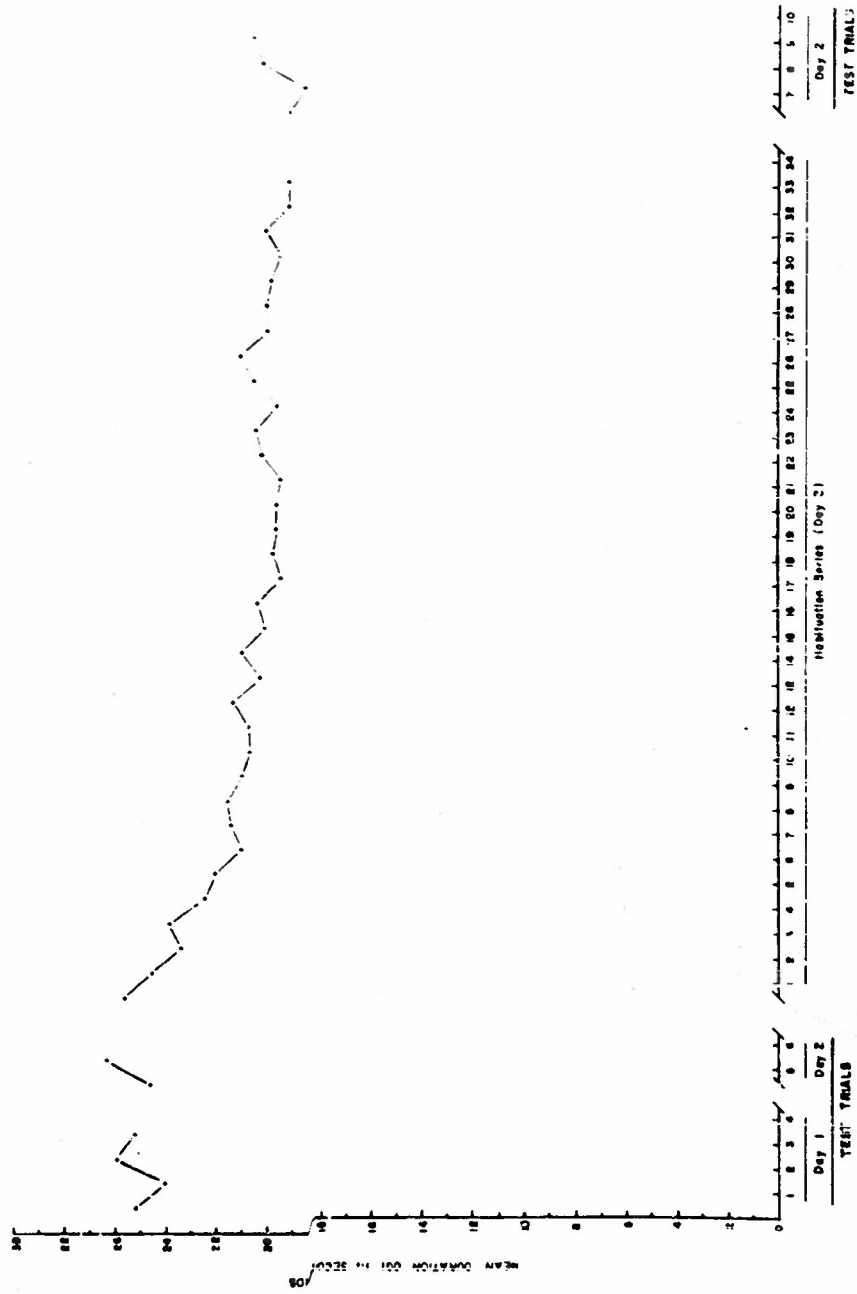FIG. 2. THE HABITUATION SERIES AND TEST TRIALS OF GROUPS I AND II.

FIG. 3. THE HABITUATION SERIES AND TEST TRIALS OF GROUP III